SPATIAL ANALYSIS OF SALT SPRINGS EXPLOITATION IN MOLDAVIAN PRE-CARPATIC PREHISTORY (ROMANIA)

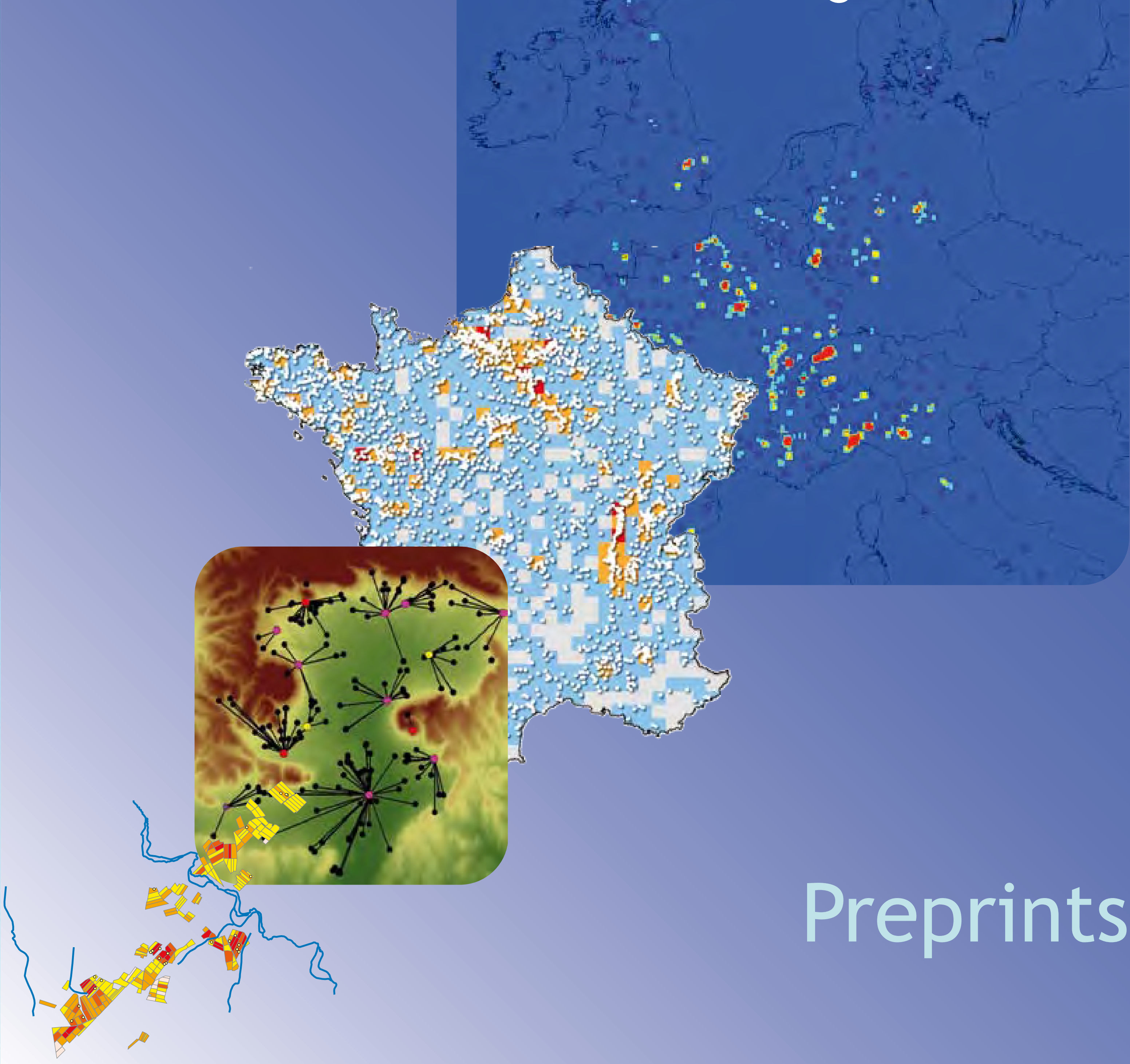
Olivier Weller, Robin Brigand, Laure Nuninger

ACI "Spaces and territories" 2005-2007
Final conference - Dijon, 23-25 june 2008

ARCHAEDYN

7 millennia of territorial dynamics

settlement pattern, production and trades from Neolithic to Middle Ages



Preprints

Pre-proceedings directed by

Cristina GANDINI *(UMR 8546 AOROC, ENS Ulm Paris)*
François FAVORY*
Laure NUNINGER*

Organisation committee

Cristina GANDINI,
Laure SALIGNY***
Laëtitia BASSEREAU**
Jean-Marc BOURGEON***
Brigitte COLAS**
Marion LANDRÉ****
Isabelle MOURET****
Sophie BUI****
Sylvie COSTILLE-VAREY*
Nathalie PUILLET*

Scientific committee co-chairs

François FAVORY*
Claude MORDANT**
Laure NUNINGER*

** UMR 6249 ChronoEnvironnement*
*** UMR 5594 ARTeHIS*
**** MSH Dijon UMS 2739*
***** MSH C. N. Ledoux, Besançon USR 3124*

ACI « Spaces and territories » 2005-2007

Contract ET 28

Spatial dynamics of settlement and natural ressources : toward an integrated analysis over the long term from Prehistory to Middle Ages

Final Conference – University of Burgundy, Dijon, 23-25 june 2008

ARCHÆDYN

7 millennia of territorial dynamics

settlement pattern, production and trades from Neolithic to Middle Ages

Preprints

SPATIAL ANALYSIS OF SALT SPRINGS EXPLOITATION IN MOLDAVIAN PRE-CARPATIC PREHISTORY (ROMANIA)

Olivier Weller[1], Robin Brigand[2] and Laure Nuninger[2]

[1]*Protohistoire européenne, UMR 7041 ArScAn, CNRS-Universités Paris I et Paris X*
olivier.weller@mae.u-paris10.fr

[2]*Chrono-environnement, UMR 6249, LEA ModeLTER, CNRS-Université de Franche-Comté*
robin.brigand@univ-fcomte.fr
laure.nuninger@univ-fcomte.fr

Abstract:

This paper presents the first results of the spatial analysis concerning the dynamics and interaction between settlement patterns from the Neolithic to Chalcolithic times (6000-3500 BC) and a particular mineral resource exploited since the Early Neolithic, the salt springs in the Oriental Carpathian Mountains. Using kernel densities and viewsheds, we propose some natural and anthropological factors which structure this regional territory.

Key words : Settlement patterns, salt spring, Neolithic-Chalcolithic, Romania, Moldova

This paper aims at presenting part of an interdisciplinary French-Romanian project focusing on the dynamics and interactions between human societies and a particular mineral resource, the salt springs. The Oriental Carpathian Mountains in Romanian Moldova offer a perfect research area for studying the continued exploitation of salt springs from Neolithic times to the present. This poster focuses on the relation between Neolithic-Chalcolithic settlements (6000-3500 BC) and distribution of salt springs in the Neamt department, where we have direct evidence of their exploitation since the Early Neolithic (Weller, Dumitroaia, 2005).

1. Objectives and methodology

In order to better understand the evolution of the relation between Man and the environment, notably human settlements and salt springs, our general approach is interdisciplinary (Weller *et al.*, 2007a) and involves the following:

- Archaeological field-walking around the salt springs, identifying prehistoric techniques of exploitation , chronological and exploitation dynamics (Weller *et al.*, 2007b);
- Paleo-environmental analysis of pollen, charcoal and remains of soil combustion (Weller *et al.*, 2008a);
- Spatial analysis, using GIS to correlate archaeological and salt resource databases, settlement networks, viewshed and access (Weller, Nuninger, 2005; Weller *et al.*, 2008b);
- Ethnographic investigations around the salt resources (Alexianu, Weller, 2008);
- Geological and chemical analyses of the salt springs.

Among these approaches, this study focuses on the spatial archaeological approach involving GIS. The aim is to explore: 1) how did the salt springs, exploited or not, impact the settlement patterns during the Neolithic and Chalcolithic periods; 2) what are the ways in which the salt resources, production and circulation were controlled.

2. Settlement patterns over times

The first step of this project aims at analysing the relationship between settlement patterns and the distribution of salt springs over time. Our GIS includes an archaeological database (241 sites and 79 springs of which 58 are salty and 8 are exploited) mainly based on fieldwork records (GPS measurements), a digital elevation model with a resolution of 25 m made from satellite imagery by K. Ostir (IASS, ZRC SAZU, Slovenia) and the administrative district map on the level of the village (M. Consinschi, University of Lausanne).

First, we developed a mapping approach based on municipality units for the Neamt department (area 2, fig. 1). Using a selection of reliable archaeological sites (184 out of 241), we attempted to show the relationship between the settlement density and the

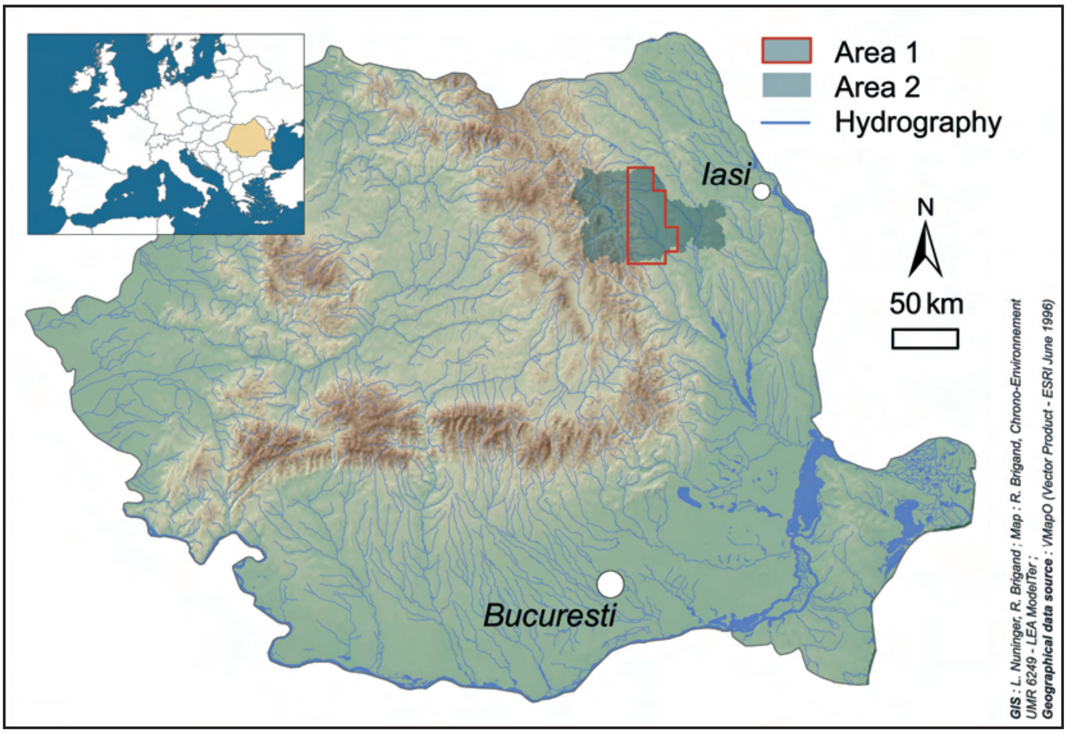


Fig. 1: Study areas in Romania

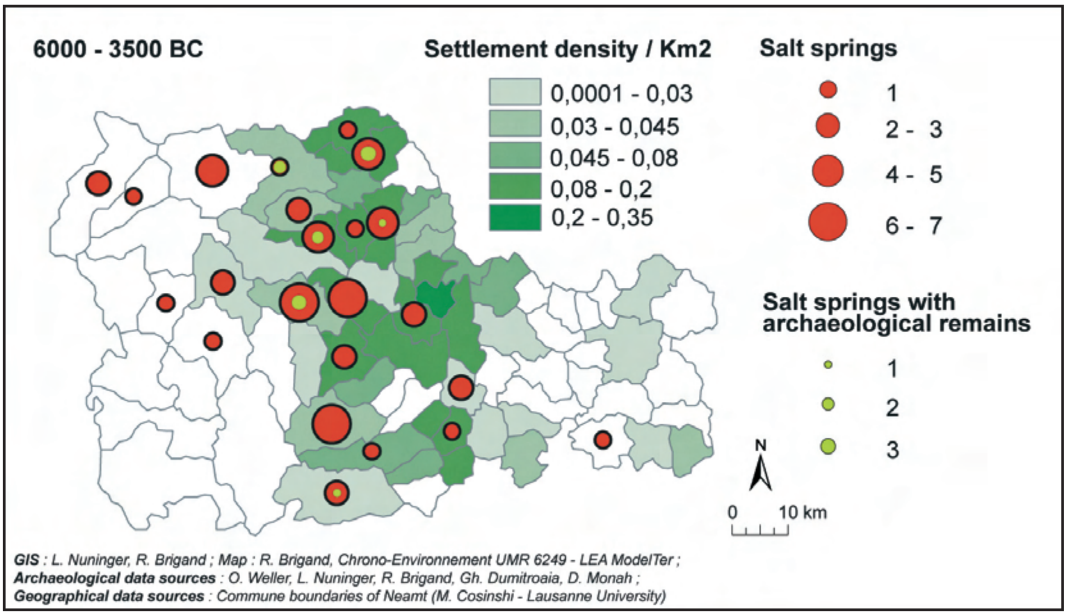


Fig. 2: Settlement density and salt springs

number of salt springs (fig. 2). With the exception of the area of the Carpathian Mountains, where the archaeological inventory is probably less reliable, this first map shows interesting results. In general, during the period studied, the high occupation density of salt springs is undoubtedly to the detriment of alluvial plains in the east and the Carpathian Mountains on the southwest. In detail, in the Pre-Carpathian Mountains, even if the higher number of salt springs is usually located within a settlement of high density, there is no strict correlation and some highly inhabited areas do not have any salt resources in their vicinity. Regarding occupation type, the settlements on high position are well linked to the location of salt springs. Such observations suggest a specific organisation of the settlement pattern which is in all likelihood associated to the salt resource economy, but probably complex and not directly linked to the exploitation of salt springs.

The settlement pattern changes over time (fig. 3) were quantified by using mapping and the kernel density estimation method (KDE) to improve the first approach in the Carpathian foothills (area 1, fig. 1). The KDE method provides an estimation of density for a surface using the value from a starting point which decreases as soon as the distance increases, and according to the model of curve chosen (kernel function). The kernel function used is based on a quadratic kernel function (Silverman, 1986). Since the result of the analysis is not strongly influenced by the kernel function as long as the function

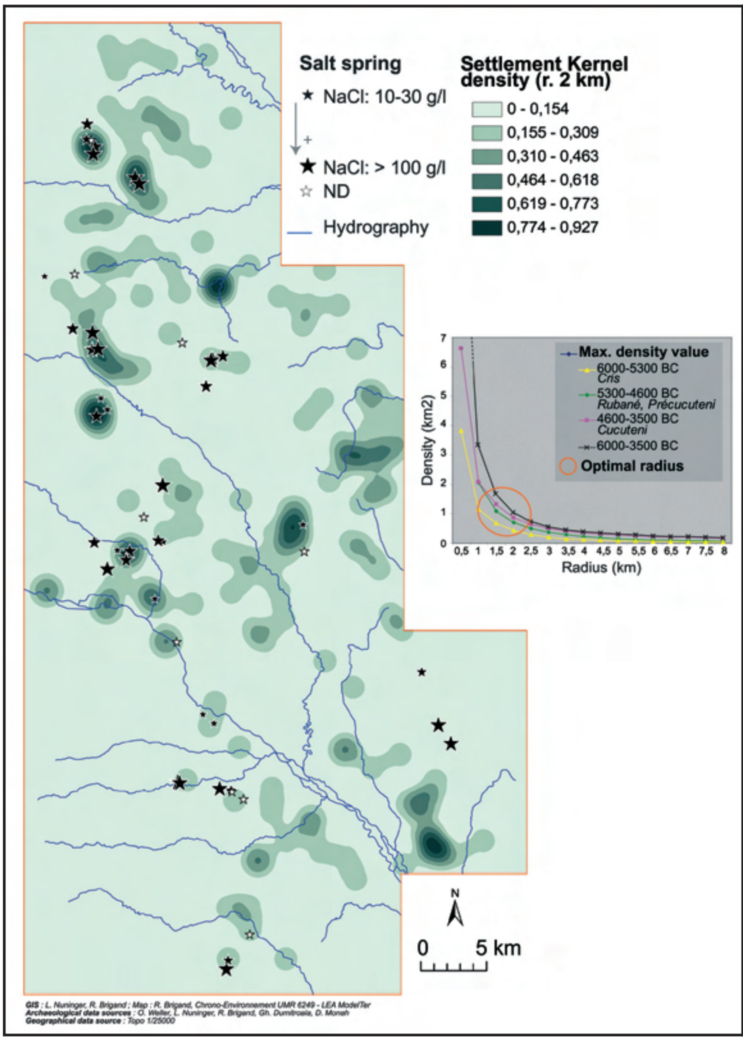


Fig. 3: Spring salinity and occupation density between 6000-3500 BC

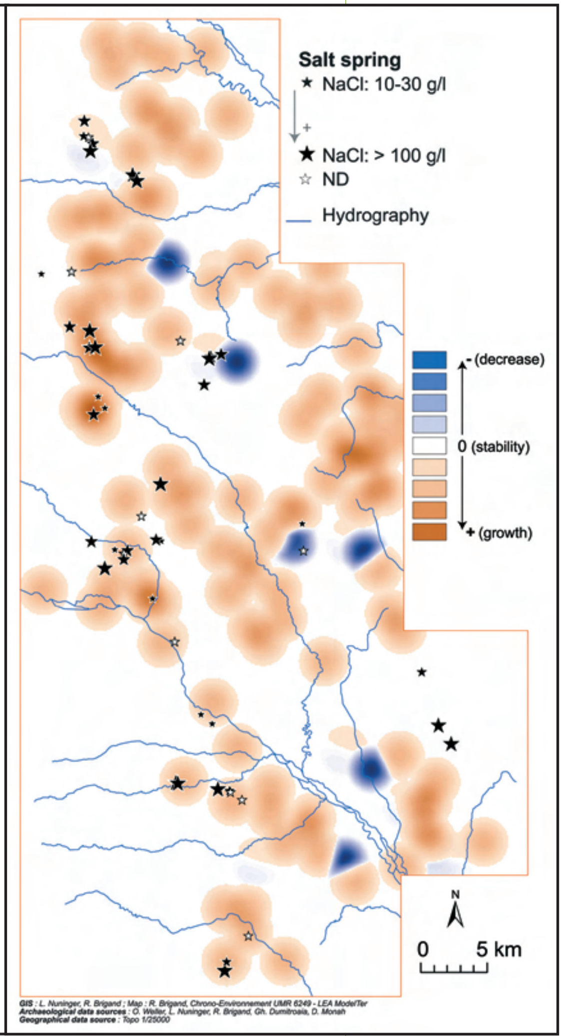


Fig. 4: Settlement dynamics between 5300 and 3500 BC

is symmetrical (Silverman, 1978), we did not do any tests with other kernel functions. On the other hand, the choice of the width of the window and the radius is very important (Silverman, 1978). Since our approach was exploratory, we used the graphical method defined by F. Tolle, ThéMA (UMR 6049) to determine the optimal radius. Thus, the final choice in our case was a radius between 1.5 and 2 km (fig.3). The results show that most of the salt springs are located in prehistoric settlements of higher density during the entire period. In reality, the Neolithic archaeological sites show the main background tendencies which insure the Chalcolithic demographic development.

The same KDE method was used to compute density per chrono-cultural period (about 1 millennium for each period). By subtracting the values of the KDEs of the Middle-Late Neolithic (5300-4600 BC) from these of the Cucutenian period (4600-3500 BC), an overview of the settlement pattern dynamics is obtained according to its stability or instability (fig. 4). The main axes of circulation and a majority of the highly salted springs are the object of settlement densification, in particular during the first period of Cucuteni (4600-4000 BC).

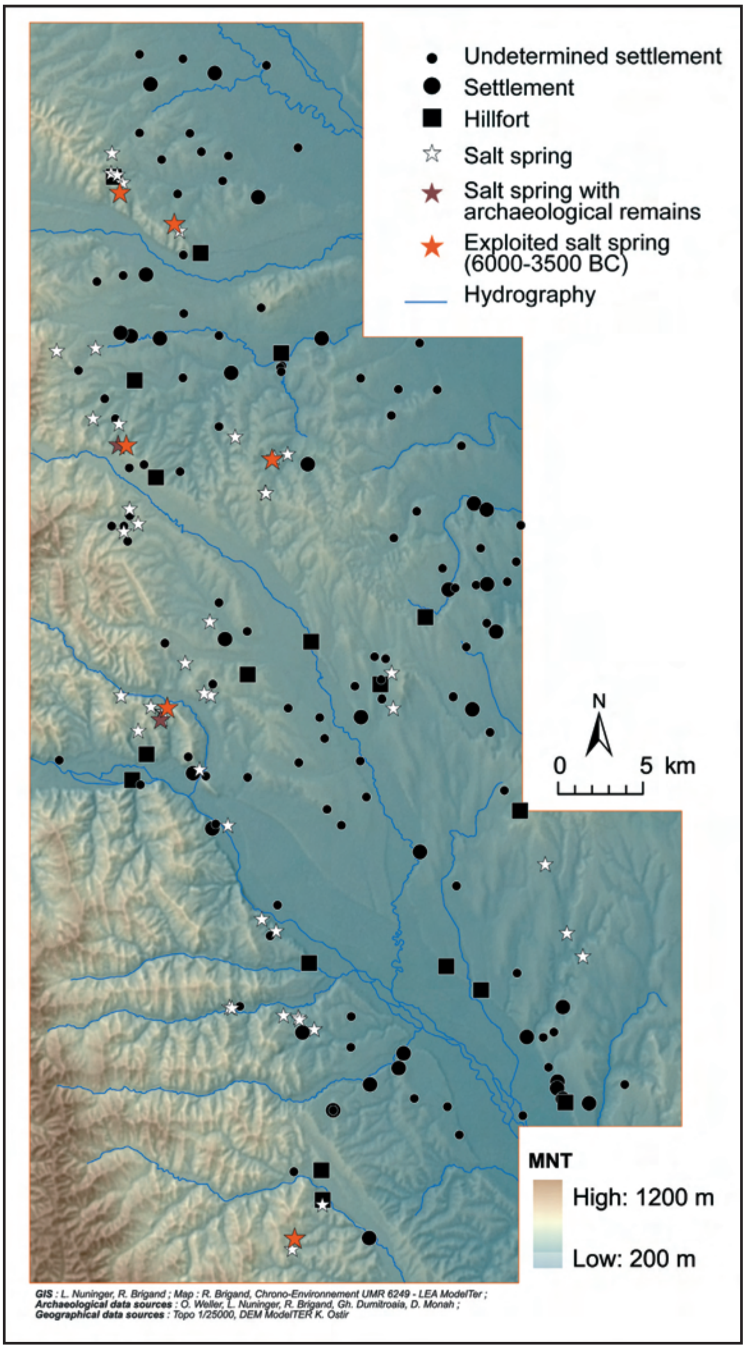


Fig. 5: Fortified villages, settlements and salt springs

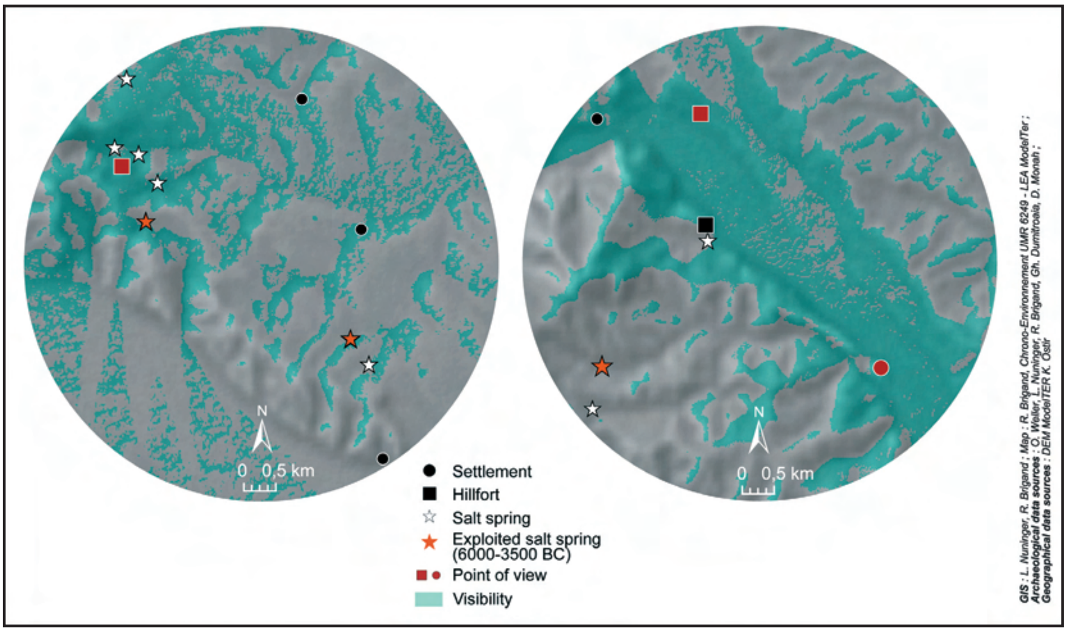


Fig. 6: Viewshed analysis: 2 types of visual control

3. Territorial control

A qualitative approach is in progress in order to qualify the type of control practised on salt resources, production and circulation. First, we mapped the distribution of salt springs, with or without archaeological remains of exploitation, and the distribution of high ground settlements in area 1 (fig. 5). Direct and systematic links were not observed, except in some cases.

With the 25 m Digital Elevation Model, a simple viewshed analysis was processed from the perspective of archaeological sites. The preliminary results show that two modes of visual control can be defined: 1) a direct visual control of the salt springs (example of Cetatuia promontory village, fig. 6-left); 2) an indirect visual control which impacts the main access (example of Tazlau valley, fig. 6-right). In this last case, the fortified

sites of Cucuteni A located on the right and left sides of the Tazlau River (Cetatuia and La Coboras) were taken into account. Their visibilities were overlaid to define the visual control area. The visual control of the salt springs is null from both settlements, even from the exploited ones where archaeological remains have been found, but the control of the Tazlau Valley and the access to the salt spring valley seems to be optimal. A third one, a promontory settlement, within the visual control of both main settlements, is well located to control a secondary access to the salt spring. It is probably an intermediate settlement which served as a relay for more accurate territorial control.

This preliminary analysis has to be improved by testing several types of viewshed processing, and generalized for all the study areas in order to characterize the visual system of control (hierarchical organization of sites according to the size of visual space, the number of visible sites and the number of sites which can be seen from each site).

On the scale of the Pre-Carpatic Mountains, the results of the spatial analysis suggest that the Chalcolithic occupation (4600-3500 BC) integrates a complex settlement pattern in which the network and hierarchical organization of settlement has to be recognized. Apprehending these networks, still in its forward-looking phase, brings to light the importance of areas under visual control or densely inhabited, even if there is no direct relationship with the location of salt springs. In a region known for the important economical role of salt (Weller, Dumitroaia, 2005; Alexianu, Weller, 2008), the study of such "disconnected" areas is promising for territorial issues since their presence likely underlines a high level of social organisation.

Acknowledgments

This project has been supported since 2004 by the CNRS (Humanities Department), the French Foreign Office and the University of Franche-Comté, and is developed in association with the Museum of History and Archaeology in Piatra Neamt, the Al.I. Cuza University and the Archaeological Institute in Iasi (Romania). This English version was revised thanks to the support of the ArchaeDyn programme.

Bibliography

ALEXIANU, WELLER, BRIGAND 2008 (in press)
Alexianu M., Weller O., Brigand R. – Usages et enjeux autour des sources salées de Moldavie précarpatique, Roumanie. *In* : O. Weller *and al.* (eds.), *Sel, eau et forêt : hier et aujourd'hui*. Colloque international, Saline royale d'Arc-et-Senans, 2006. Besançon, Presses Universitaires de Franche-Comté, Cahiers de la MSH Ledoux (coll. Homme et environnement, 1).

SILVERMAN 1978
Silverman B. W. – Choosing the window width when estimating a density, *Biometrika*, 65-1 : 1-11.

SILVERMAN 1986
Silverman B. W. – *Density Estimation for Statistics and Data Analysis*. Monographs on Statistics and Applied Probability, London, Chapman and Hall.

WELLER, BRIGAND, ALEXIANU 2007 B
Weller O., Brigand R., Alexianu M. – Cercetari sistematice asupra izvoarelor de apa sarata din Moldova, *Memoria Antiquitatis*, XXIV.

WELLER, BRIGAND, NUNINGER, DUMITROAIA, MONAH 2008 B (in press)
Weller O., Brigand R., Nuninger L., Dumitroaia Gh., Monah D. – Analyses et modélisation spatiale autour des sources salées de Moldavie précarpatique durant la Préhistoire. *In* : N. Morère Molinero (ed.), *Las salinas y la sal de interior en la historia : economía, medioambiente y sociedad*, colloque international, Sigüenza, 2006. Madrid, Universidad Rey Juan Carlos-Dykinson.

WELLER, DUMITROAIA 2005
Weller O., Dumitroaia Gh. – The earliest salt production in the world : an early Neolithic exploitation in *Poiana Slatinei*-Lunca, Romania, *Antiquity*, 79 (306).
www.antiquity.ac.uk/ProjGall/weller/index.html

WELLER, DUMITROAIA, MONAH, NUNINGER 2007 A
Weller O., Dumitroaia Gh., Monah D, Nuninger L. – L'exploitation des sources salées en Moldavie : un exemple de ressource structurante du territoire depuis le Néolithique. *In* : D. Monah *and al.* (eds.), *L'exploitation du sel à travers le temps.* Colloque international de Piatra Neamt (Roumanie), 2004. Piatra Neamt, Bibliotheca Memoriae Antiquitatis, XVIII : 99-113.

WELLER, DUMITROAIA, SORDOILLET, DUFRAISSE, GAUTHIER, MUNTEANU. 2008 A (in press)
Weller O., Dumitroaia Gh., Sordoillet D., Dufraisse A., Gauthier E., Munteanu R. – Première exploitation de sel en Europe : Techniques et gestion de l'exploitation de la source salée de Poiana Slatinei à Lunca (Neamt, Roumanie). *In* : O. Weller *and al.* (eds.), *Sel, eau et forêt : hier et aujourd'hui*. Colloque international, Salines royales d'Arc-et-Senans, 2006. Besançon, Presses Universitaires de Franche-Comté, Cahiers de la MSH Ledoux (coll. Homme et environnement, 1).

WELLER, NUNINGER 2005
Weller O., Nuninger L. – Les eaux salées de Moldavie roumaine : étude interdisciplinaire autour d'une ressource structurante du territoire. *In* : J.F. Berger *and al.* (eds.), *Temps et espaces de l'Homme en société, analyses et modèles spatiaux en archéologie*. XXVe Rencontres internationales d'Histoire et d'Archéologie d'Antibes, 2004. Juan-les-Pins, APDCA : 511-516.

SOMMAIRE CONTENTS